U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-266 391

Immediate Water Pollution Control Needs St. Francis River Basin Missouri and Arkansas

Federal Water Pollution Control Administration, Dallas, Tex

Apr 67

PB 266 391

IMMEDIATE WATER POLLUTION CONTROL NEEDS

ST. FRANCIS RIVER BASIN

MISSOURI AND ARKANSAS

UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTH CENTRAL REGION
DALLAS, TEXAS 75202

APRIL 1967

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE	5. REPORT DATE
IMMEDIATE WATER POLLUTION CONTROL NEEDS ST. FRANCIS RIVER BASIN MISSOURI AND ARKANSAS	April 1967
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
Federal Water Pollution Control Administration Dallas, Texas	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Environmental Protection Agency 1201 Elm Street Dallas, Texas 75270	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The purpose of the report is to focus attention on known sources of pollution in this area and to provide a priority for action to correct existing problems and to prevent future problems.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Water Pollution Control St. Francis River BAsin Missouri Arkansas		

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release unlimited - available from NTIS		24
	20. SECURITY CLASS *(This page)*	22. PRICE PC A02, MF A01

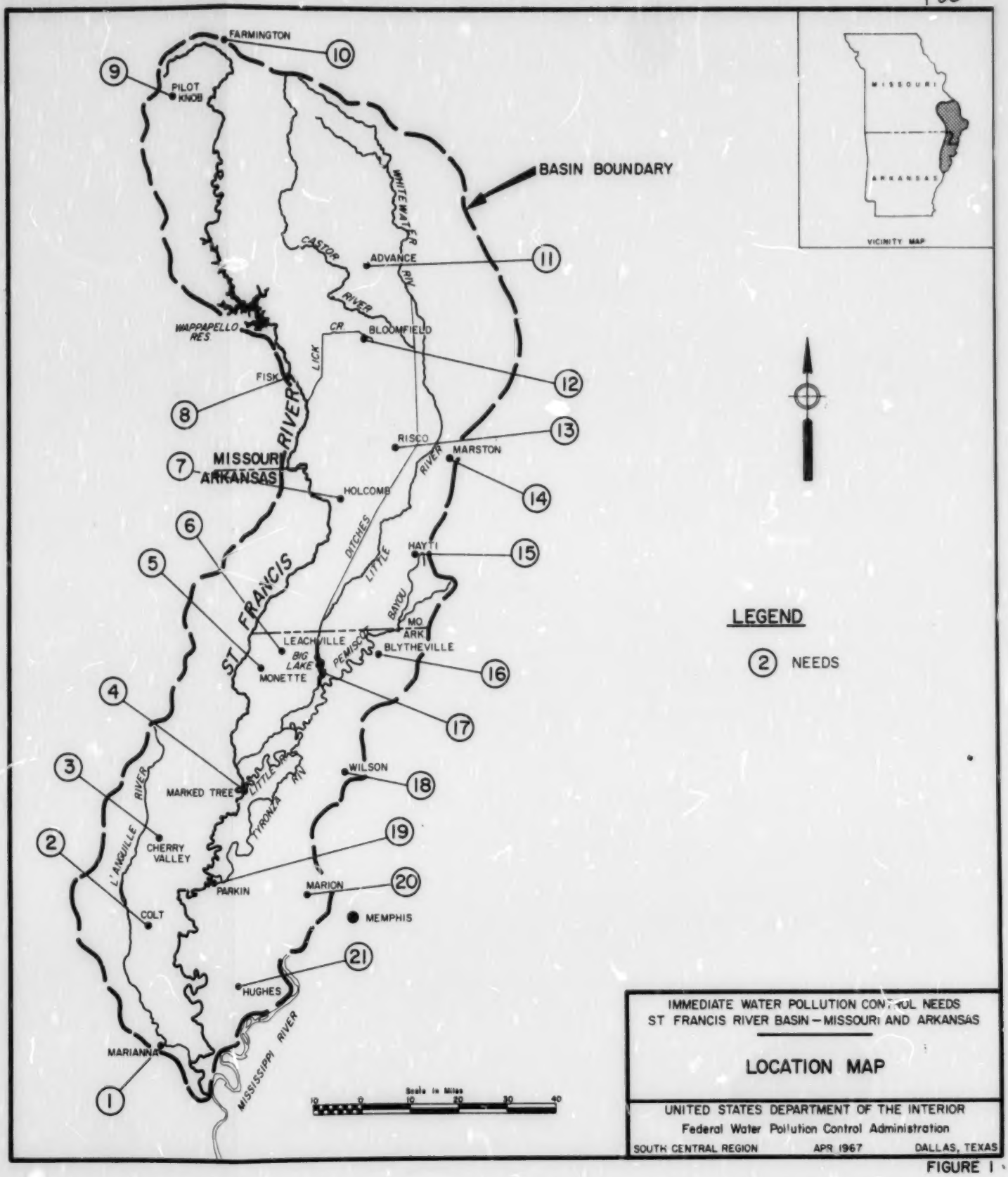
EPA Form 2220-1 (9-73)

I. Introduction

The purpose of this report is to focus attention on known sources of water pollution and to provide a priority for action to correct the existing water pollution problems and prevent future problems in the St. Francis River, an interstate stream, and its tributaries (see Figure 1). This report is based on compilation of available data of the Federal Water Pollution Control Administration, South Central Region, and the water pollution control agencies of Arkansas and Missouri. No detailed water quality surveys or engineering studies were carried out for the preparation of this report.

The findings of this report are based upon the best information available at this time on water quality conditions and immediate and potential water pollution abatement needs. The omission of any particular town, industry, or other establishment from this report does not imply that an immediate or potential water pollution abatement need does not possibly exist in that particular area. Priorities listed are based solely on an evaluation of the St. Francis River Basin and not on a relative basis with other basins in the South Central Region, FWPCA.

Section 3 (a) of the Federal Water Pollution Control Act, as amended, (33 U.S.C. 466 et seq), authorizes the preparation or development of comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof and improving sanitary conditions of surface and underground waters. This report, describing the immediate needs for controlling water pollution in the St. Francis River Basin, represents the first step in the development of a comprehensive program to control water pollution in this basin.



IMMEDIATE WATER POLLUTION CONTROL NEEDS
ST FRANCIS RIVER BASIN – MISSOURI AND ARKANSAS

LOCATION MAP

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION APR 1967 DALLAS, TEXAS

FIGURE 1

II. Summary

Pollution problems in the St. Francis River Basin indicated by fish kills, oxygen depletion, and turbidity result in damages to propagation of fish, water supply, and recreation uses. The immediate pollution control needs are listed in the following tabulation grouped into categories: waste treatment, flow regulation, other pollution control practices, institutional practices, and research. Location designations refer to Figure 1.

Waste Treatment

Location	Responsibility	Need	Priority
1	City of Marianna, Ark.	Add secondary treatment plant	(A)
	Douglas & Lomason near Marianna, Ark.	Treat plating wastes	(A)
	St. Francis National Forest near Marianna, Ark.	Primary & secondary treatment	(B)
2	City of Colt, Ark.	Primary & secondary treatment	(B)
3	City of Cherry Valley, Ark.	Primary & secondary treatment	(B)
4	City of Marked Tree, Ark.	Primary & secondary treatment	(A)
5	City of Monette, Ark.	Add secondary treatment	(A)
6	City of Leachville, Ark.	Add secondary treatment	(A)
7	City of Holcomb, Missouri	Sewage collection system, primary & secondary treatment	(B)
8	City of Fisk, Missouri	Sewage collection system, primary & secondary treatment	(B)

Waste Treatment (Continued)

Location	Responsibility	Need	Priority
9	City of Pilot Knob, Mo.	Primary & secondary treatment	(B)
10	Farmington State Hospital, Mo.	Connect to municipal sewer system	(A)
11	City of Advance, Mo.	Primary & secondary treatment	(A)
12	City of Bloomfield, Mo.	Expand existing primary & secondary treatment	(B)
13	City of Risco, Mo.	Primary & secondary treatment	(B)
14	City of Marston, Mo.	Sewage collection system, primary & secondary treatment	(B)
15	City of Hayti, Mo.	Expand existing primary & secondary treatment	(B)
16	City of Blytheville, Ark.	Expansion of existing primary & secondary treatment	(A)
	Blytheville Air Force Base	Expansion of existing primary & secondary treatment	(A)
18	City of Wilson, Ark.	Primary & secondary treatment	(A)
19	City of Parkin, Ark.	Add secondary treatment	(A)
20	City of Marion, Ark.	Add secondary treatment	(A)
21	City of Hughes, Ark.	Expand or modify present treatment facilities	(A)

Flow Regulation

Location	Responsibility	Need	Priority
17	Corps of Engineers	Routing of floodwaters and drainage system around Big Lake to control silt	(A)

Other Pollution Control Practices

Basin wide	Agricultural Activities	Improvement of land management	(A)
		Construction of flood retarding and silt retention structures in cooperation with USDA.	(B)
Basin wide	USDA	Providing of an education and training program on proper use of pesticides and herbicides, including aerial application.	(A)

Institutional Practices

Basin wide	States of Missouri and Arkansas	Adopt water quality standards as required by the Federal Water Pollution Control Act, as amended, for the St. Francis River and its interstate tributaries. In addition, standards for intrastate streams of the basin should be adopted in consistency with the interstate stream standards to provide for basin wide water quality preservation. These standards should clearly recognize the basin's principle water uses, irrigation, fish and wildlife, and recreation.	(A)
Basin wide	States of Missouri and Arkansas	Both states of this basin should consider legislation to provide appropriations for State participation in grants for construction of sewage treatment works.	(B)
Basin wide	States of Missouri and Arkansas	Both states of the basin should consider legislation to control	(A)

Institutional Practices (Continued)

Location	Responsibility	Need	Priority
		use of pesticides and herbicides to reduce the hazard from this source of pollution.	
Basin wide	States of Missouri and Arkansas	Cooperate in the establishment of a basin wide planning organization for control of silt pollution in the St. Francis River Basin.	(A)
Basin wide	States of Missouri and Arkansas	Both states should expand water pollution surveillance staffs for this basin and those adjoining so that problems can be inventoried, corrective actions promoted, continuous surveillance of water quality and follow-up of water pollution control measures provided.	(A)
Basin wide	Every municipality and industry	Provide for improved operation and maintenance of existing water pollution control facilities to assure uninterrupted, effective treatment of all wastes before release to basin waters.	(B)
Research			
Basin wide	Pesticide producers and USDA	Develop pesticides and herbicides which are toxic to specific organisms but have little or no effect on aquatic life. The use of these agricultural materials, following their development, should be promoted by the United States Department of Agriculture and the Federal Water Pollution Control Administration.	(B)

III. Immediate Control Needs

The most pressing water pollution control need in the St. Francis River Basin is the prevention of water quality deterioriation resulting from agricultural activities. The major agricultural pollutants at this time are silt and pesticides. Silt enters the basin streams as the result of erosion of the land during heavy rainfall. In general, the pesticide problem results from improper use of insecticides on the crops of the basin and by improper aerial spraying practices. Legislation and training in land conservation and pesticide use are needed to abate the pollution resulting from agricultural activities.

Control of siltation

Control of siltation is best accomplished by preventing the silt from reaching gulleys, ditches and streams. Improved land management practices will need to be applied to control the silt problem. Erosion is an economic loss to the farmer and it is to the farmer's benefit to prevent erosion. Those responsible for the agricultural activities of the basin will need to learn and practice methods of land management which will prevent erosion. Examples of land treatment methods which can be instituted by the individual farm operators to effectively control erosion are: strip cropping, maintenance of crop cover during the rainy season, contour cultivation and the provision for grass-lined waterways to carry off excess water.

In addition to improved land treatment practices, various control devices to retard run-off and decrease its velocity should be installed as a part of the siltation control program. These devices will range from check dams and protected waterways provided on individual farms up to larger works such as flood water retarding structures and sediment detention basins which will need to be provided by local institutions such as soil conservation districts.

The United States Department of Agriculture, Soil Conservation Service, is well versed in the application of the methods of erosion control and carries out an active program of soil conservation and flood control. The Federal Water Pollution Control Administration should coordinate the efforts of the Department of Agriculture with the water pollution control agencies of Missouri and Arkansas to hasten the implementation and carrying out of an effective basin wide erosion control program.

Control of Pollution Caused by Agricultural Chemicals

The use of agricultural chemicals is a necessary part of the agricultural activities in the St. Francis River Basin. The use of herbicide and insecticide materials increases the value of crops harvested in this basin. However, the use of these chemicals has in many cases resulted in stream degradation as a harmful side effect.

The two most important considerations in the use of pesticides is the dose per unit of area and the method of application. Each pesticide has its own characteristics, requiring a specific dose rate and application method. Those persons responsible for the use and application of pesticides will need to learn the proper methods for applying each pesticide and herbicide. Such an educational program could be carried out in local areas in short, informal courses conducted jointly by the training program of the Department of Agriculture and the Federal Water Pollution Control Administration.

Effective regulation of the time and place that particular chemicals may be used should be instituted. Many counties in various states already require permits to use highly toxic pesticides. Such regulation should have as a prime goal the prevention of pesticide use except when it is absolutely necessary. State laws on the use of pesticides together with strong enforcement should be adopted. One part of the state program should require the examination and licensing of all pesticide and herbicide contractors. It is conceivable that the use of certain highly toxic pesticides would be prohibited. It should be noted that legislation has recently been introduced into the Missouri Legislation which would require licensing of pesticide contractors and provide other needed controls.

Control of pollution resulting from the use of highly toxic pesticides will largely depend on finding suitable substitutes which are just as effective against pests but are not highly toxic to beneficial forms such as aquatic life. All presently available pesticides should be investigated to see if those which are less toxic to fish could be used just as well as those highly toxic compounds now being used. In addition, basic research to develop new pesticides which are still effective against pests but not highly toxic to aquatic life should be increased. This research should seek pesticides which are highly target specific and do not persist in the environment for long periods. Such pesticides should also readily decompose in the aquatic environment.

When more desirable pesticides have been found, the users must be notified of their availability. Such pesticides must be competitively priced if their widespread use is to become a reality. It is suspected that highly toxic insecticides such as toxaphene are used today because of their price advantage.

Control of Other Forms of Pollution

The following actions, in addition to those described above, are necessary to protect the use and quality of the St. Francis River Basin water:

Farmington State Hospital, Missouri, should be connected

to the municipal sewer system; Advance, Missouri, requires secondary treatment for their wastes; Marked Tree and Wilson, Arkansas, need sewage treatment and should provide primary and secondary treatment in order to protect the waters to which their wastes are discharged; Blytheville, Arkansas, and the Blytheville Air Force Base both are plagued by overloading of the existing sewage treatment plants as the result of infiltration. Therefore, both primary and secondary treatment portions of these plants need to be expanded in order to provide adequate treatment of the wastes to be discharged. The plating waste generated at the Douglas and Lomason plants at Marianna, Arkansas, should be treated to remove toxic and noxious substances prior to discharge to the waters of the basin. The following municipalities provide primary treatment and need to add secondary treatment to their existing plants in order to provide adequate treatment prior to discharge to basin streams: Marianna, Leachville, Monette, Marion, and Parkin, Arkansas. Hughes, Arkansas, requires modification or expansion of the existing treatment facilities.

The list of needs is not considered all inclusive and does not reflect the ultimate in precision and detail in evaluating alternatives. It does not reflect projected needs due to future obsolescences or to expanded or changed water uses. The actions recommended here are, however, prerequisite to good water quality planning and should be included in local and state programming for water pollution control. Background for these immediate needs is summarized in Chapter VI.

IV. Costs

The control of water erosion and pesticides in the St. Francis River Basin would require the expansion of existing programs and the cooperative development of new programs. Actual cost figures for control features must necessarily await the planning and formulation of these new and expanded programs. The following outline provides a list of the major steps necessary to bring about the needed water pollution control programs. When sufficient planning has been accomplished, cost figures can be developed for each of the items listed.

CONTROL PROGRAM ITEMS

I. Erosion Control
   - A. Land Management Methods
     1. Field Surveys of erosion areas
     2. Planning of a complete basin erosion control program
     3. Design of controls for individual farms
     4. Assistance in constructing needed farm control devices
   - B. Structural Measures
     1. Planning and design of needed control structures
     2. Construction of needed control structures

II. Pesticide Control
   - A. Training of pesticide operators
   - B. Drafting of model local regulations governing pesticide usage.
     1. Dissimination of model regulations
     2. Gaining adoption of local regulations
   - C. Drafting of model state laws governing use of pesticides and requiring examination and licensing of pesticide operators
     1. Dissimination of model state laws
     2. Gaining adoption of state laws
   - D. Investigation of available pesticides
   - E. Research for new pesticides
     1. Dissimination of information regarding use of more target-specific pesticides
     2. Develop pricing program to gain acceptance of more desirable pesticides.

Other Control Needs

Estimates of the cost of waste treatment measures recommended in

this report indicate that about $5,285,000 must be invested in municipal and industrial waste treatment facilities over the next five years.

Estimation of the cost of management procedures, institutional practices, and water pollution control surveillance, will require more detailed study and planning than was available in preparing this report. Federal Water Pollution Control Administration should undertake to develop these data in cooperation with the State water pollution control agencies of Missouri and Arkansas.

V. Recent Progress in Pollution Control

Most of the larger mechanical waste treatment plants in the Missouri portion of the basin were built prior to 1960. In recent years, many small communities have installed sewers and constructed lagoons. The Missouri Water Pollution Board has established a series of water quality monitoring stations in the headwaters of the St. Francis River Basin in order to detect any changes in water quality due to the lead and iron mining operations in the upper basin. The Board has initiated surveys to determine water quality and locate problems of all Missouri streams. Surveillance stations have been established on the interstate streams of the St. Francis River Basin to monitor water quality as the river enters Arkansas.

Regional schools to train waste treatment plant operators are being set up by the Missouri Water Pollution Board. The Board is also lending its support to a proposed State law which would require licensing of all waste treatment plant operators. An operations and maintenance section is planned by the Board as soon as personnel can be found to staff it. Surveys, technical advice, and operation problems would be handled by this new staff. The Board has determined that all municipal and industrial wastes discharged in the St. Francis River Basin must receive no less than secondary treatment.

The Arkansas Water Pollution Control Commission is carrying out an active program to secure modernization and expansion of outdated and undersized waste treatment plants in the St. Francis River Basin. The Commission has been successful in getting all the communities in the basin to provide waste treatment except for three communities that have treatment plants under construction. Securing secondary treatment of all municipal and industrial wastes discharged in the basin is another activity the Commission is actively pursuing.

Personnel of the Arkansas Water Pollution Commission visit waste treatment plants which are experiencing difficulty and advise on remedial measures to be taken. Regular visits to all treatment plants are being proposed by the Commission. These visits would be made by any one of four proposed regional people or by a staff member from Little Rock. A new staff position in Little Rock to work on operator training has been proposed. At the present time, Arkansas has a voluntary training and licensing program for waste treatment plant operators.

For some time the staff of the Commission has conducted water quality surveys of Arkansas' streams and the lower half of the St. Francis River has been surveyed in this program. The information gathered in these surveys will serve as basic data to help in

evaluating water quality problems as they develop.

The Federal Water Pollution Control Adminstration has initiated the Lower Mississippi River Comprehensive Project which will include the St. Francis River Basin.

VI. Background for Recommendations

Pertinent Basin Characteristics

The St. Francis River has its headwaters in the Ozark Mountains of Southeast Missouri and flows southward and generally parallel to the Mississippi River. It forms the boundary with Arkansas along the "boot heel" portion of Missouri and continues through Arkansas until it joins the Mississippi River near Helena, Arkansas.

The upper portion of the basin in Missouri is mountainous and sparsely settled. Below Wappapello Reservoir, (See Figure 1, Location Map), an authorized Corps of Engineer flood control project used extensively for recreation, the St. Francis River enters the level to gently rolling Mississippi Alluvial Plain. Extensive drainage and flood control works constructed throughout the Missouri and Arkansas portion of this level plain have made possible the development of an exceptional area for agriculture. The Little River drainage system in Missouri, with 980 miles of ditches draining a former marshy and heavily forested area, is the most extensively developed system.

The St. Francis River Basin drains an estimated 8,400 square miles and is an area of abundant water, with a mean annual precipitation of about 49 inches. An overabundance of water has made necessary the elaborate flood control and drainage works apparent throughout the basin. The drainage from 1,130 square miles of the basin in Northern Missouri has been diverted eastward to the Mississippi River by the Headwater Diversion Channel. This diversion was made in the early 1900's to facilitate the draining of the swamps and sloughs along the Little River. In addition to the Little River and the system of drainage ditches comprising its drainage area, the L'Anguille River on the west and the Tyronza River on the east, are major tributaries of the St. Francis River.

The flow characteristics at several locations in the St. Francis River Basin are shown in Table 1.

TABLE 1

Streamflow Characteristics - St. Francis River Basin

Stream & Location	Drainage Area	Lowest Recorded Flow	Average Flow	Median Flow	Flow Equaled or Exceeded 95%	80%
	Square Miles	cfs	cfs	cfs	cfs	cfs
St. Francis River near Patterson, Mo. (above Wappapello Reservoir)	956	8	1,100	305	30.2	73.8

TABLE 1 (Continued)

Stream & Location	Drainage Area Square Miles	Lowest Recorded Flow cfs	Average Flow cfs	Median Flow cfs	Flow Equaled or Exceeded 95% cfs	Flow Equaled or Exceeded 80% cfs
Little River Ditch #1 near Kennett, Mo.	235	8	415	150	29	78
Pemiscot Bayou near Holland, Missouri	144	(Partial record station)			17.3	21.6*
Buffalo Ditch near Arbyrd, Missouri	38.7	(Partial record station)			7.4	10.8*
Right Hand Chute of Little R. at Rivervale, Ark., (Below Big Lake)	2,113	80		1,580	226	530
St. Francis River at Marked Tree, Ark., (Including Flood Way)	5,141**	63	5,831	420	200	295
L'Anguille R. at Palestine, Ark.	307	0		455	0.5	52

* Flow equaled or exceeded 90% of time.
** Tentative-Does not include 1,130 square miles diverted to Mississippi River

The surface waters of the St. Francis River Basin during low flow periods are moderately mineralized and most are hard. The principal constituents in the water are calcium, magnesium, and bicarbonate. The water in the basin's streams during low flow periods is mainly groundwater discharge; therefore, the chemical quality of the groundwater is reflected in the surface water quality. The groundwater table lies within ten to fifteen feet of the surface in many areas. The water quality at several locations, as reflected in samples collected August 30, 1966, by the Missouri Water Pollution Board, is shown in Table 2.

TABLE 2
Water Quality - St. Francis River Basin

Stream and Location	Flow	Bicarbonate Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Turbidity	pH	Coliform Bacteria
	cfs	mg/l	mg/l	Units		MPN/100ml
Buffalo Ditch near Arbyrd, Missouri	49.8	150	192	22	7.7	100
Little River Ditch #1 near Kennett, Mo.		181	200	100	8.2	80
St. Francis River near State Line (Cardwell, Mo.)		118	133	110	7.9	100

The economy of the St. Francis River Basin is based on utilization of the area's abundant natural resources. In the upper basin, some small mining operations are carried out. There are also several slaughter houses in this area. In the remainder of the basin, agriculture is the dominant activity. When irrigation is practiced to protect the crops against the "10 day drought", groundwater is generally used. In 1964, 25,800 acres were irrigated in Missouri and 213,600 acres in Arkansas. Cotton and soybeans account for the major cash crops; corn and wheat are minor crops. The general character of the basin is definitely rural with many small agriculturally oriented communities scattered throughout the basin.

The largest Missouri town within the basin, Kennett, had a 1960 population of 9,098. The only three towns in the Arkansas portion of the basin which had a 1960 population in excess of 10,000 were Blytheville with 25,883, Forrest City with 12,032, and Paragould with 10,053. These communities serve as marketing, distribution, and service centers for the basin.

Water Quality Problems

Extremely high water quality is required by the uses that characterize the waters of this basin. Currently the waters are used for irrigation, sport fishing, waterfowl hunting, pleasure boating, canoeing and other forms of recreation and esthetic enjoyment. This basin is located within an easy drive of the Memphis metropolitan area and can be expected to develop into an extremely useful recreational area after pollution from silt is reduced.

The intensive agriculture carried out in the St. Francis River Basin creates the basin's most important water pollution problems. Table 3 illustrates the large amount of acreage devoted to the major crops grown in the basin.

Except for local problems, municipal and industrial wastes are not a problem in the St. Francis River Basin. All municipalities in the Missouri portion of the basin have secondary treatment plants in operation or under construction.

Several municipalities in Arkansas need to add secondary treatment units to their primary plants. (See summary). The towns of Marked Tree and Wilson, Arkansas, which have no waste treatment at the present time, are in the process of providing for the construction of secondary treatment plants. In addition, four Arkansas communities with a sewered population of 8,600 need to add secondary units to their primary plants and one community needs to enlarge its lagoon.

The city of Blytheville, Arkansas, with a sewered population of 21,050, needs to enlarge its present secondary plant. During wet weather, the Blytheville waste treatment plant is overloaded due to water infiltrating into the sewers. The waste treatment plant at Blytheville Air Force Base is overloaded in the same manner. Under these conditions, partially treated sewage is discharged to the sluggish ditches of this area resulting in degraded water quality menacing public health and the esthetics of these water courses.

TABLE 3
St. Francis River Basin
Acres of Major Crops Harvested

	Acres Cotton Harvested		Acres Soybeans Harvested	
	1959	1964	1959	1964
Arkansas	393,000	371,800	680,200	843,400
Missouri	245,300	210,300	436,300	519,400
Total	638,300	582,100	1,116,500	1,362,800

Most of the basin's agricultural area in Missouri is drained by the ditches of the Little River drainage system. These ditches join just north of the Arkansas-Missouri state line and discharge water from approximately 1,760 square miles of drainage area into Big Lake in Arkansas (See Figure 1, Location Map). The drainage water thus conveyed into Arkansas from Missouri is heavily laden with silt. The silt load is exceptionally heavy during flood periods due to water

erosion of the agricultural areas. This silt is creating numerous wildlife and fish management problems at the Big Lake National Wildlife Refuge. The silt is filling in Big Lake and reducing the water area of the adjoining swamp. Feed crops grown for migratory water fowl are severly restricted and fish habitat is destroyed by the silt. Light penetration is greatly reduced by the silt, thereby preventing the growth of phytoplankton and aquatic plants used for food by fish and water fowl.

The Corps of Engineers have received funds to construct an improved flood control and drainage system which will divert a portion of the silt-laden flood flows around Big Lake. The system will also provide gates and other control structures which can be used during other times to divert water as necessary.

The new drainage system around Big Lake should improve the fish and wildlife habitat in the vicinity of Big Lake, but the diverted silt-laden water will continue downstream to cause problems in other areas. The fish population in downstream waters could be significantly reduced by the silt. The land owners in the Marked Tree, Arkansas area have already complained about the silt load brought to them from upstream.

In the agriculture areas of the basin, insecticides are relied on heavily to control insect pests. The boll weevil is a problem only in the southern Arkansas portion of the basin and is very seldom found in Missouri. Mississippi and Craighead Counties in Northern Arkansas are not greatly bothered by insect pests because of the large population of beneficial insects. In Missouri, the boll worm is a major problem.

Numerous fish kills reported as attributable to the use of pesticides have occurred throughout the agricultural areas of the St. Francis River Basin. It is generally believed that some of these kills result when the aerial sprayers fail to turn off the insecticide spray as they pass over the drainage ditches. Apparently kills also occur when it rains shortly after the fields have been sprayed with insecticide. Some unexplained kills have been reported late in the growing season when no spraying is being done. It appears that there is a growing reluctance on the part of farmers and others with agricultural interests to report fish kills where agricultural operations are suspected of being the cause. For this reason, it is suspected that only a small portion of the total fish kills are presently being reported.

One of the most commonly used insecticides is toxaphene, which has a 96-hour Median Tolerance Limit for flathead minnows of 0.0051 mg/l. Other insecticides are also used together with herbicides to control the various animal and plant pests that plague the farmer.

VII. Bibliography

1. Arkansas Water Pollution Control Commission, Unpublished data and information from Commission's files, Little Rock, Arkansas, January 1967.

2. Bratton, Samuel Tilden, Ph.D., The Geography of the St. Francis River Basin, The University of Missouri Studies. Columbia, Missouri: University of Missouri, July 1926.

3. Hines, Marion S., Water-Supply Characteristics of Selected Arkansas Streams, Water Resources Circular No. 9. Little Rock, Arkansas: Arkansas Geological Commission, 1965.

4. Missouri Water Pollution Board, "Statements and Data presented at Hearing on Water Quality, Mississippi River and St. Francis River," held at Kennett, Missouri, December 9, 1966.

5. Skelton, John, Low-Flow Characteristics of Missouri Streams, Water Resources Report 20. Rolla, Missouri: Geological Survey, July 1966.

6. Skrinde, Rolf T., John W. Caskey, and Charles K. Gillespie, "Detection and Quantitative Estimation of Synthetic Organic Pesticides by Chromatography," Journal, American Water Works Association, Vol. 54, No. 11, November 1962.

7. U. S. Department of Commerce, Bureau of the Census, United States Census of Agriculture, 1959, 1964 - Arkansas, Missouri, "Counties." Washington, D. C., Government Printing Office.

8. U. S. Department of Commerce, Bureau of the Census, United States Census of Population, 1960 - Arkansas, Missouri, "Number of Inhabitants." Washington, D.C., Government Printing Office.

9. U. S. Department of Health, Education, and Welfare, Public Health Service, 1962 Inventory Municipal Waste Facilities, "Region VII." Washington, D.C., Government Printing Office.

10. U. S. Department of Health, Education, and Welfare, Pollution Caused Fish Kills in 1963, 1964. Washington, D.C., Government Printing Office.

11. U. S. Department of Health, Education, and Welfare, Water Resources Study, Marked Tree Siphon, St. Francis River Basin, Arkansas. Dallas, Texas, Region VII: Division of Water Supply and Pollution Control, February 1963.

12. U. S. Department of the Interior, Geological Survey, Water Quality Records in Arkansas, various years through 1964. Little Rock, Arkansas: U. S. Geological Survey.

13. U. S. Department of the Interior, Geological Survey, Water Quality Records in Missouri, various years through 1964. Rolla, Missouri: U. S. Geological Survey.

14. U. S. Department of the Interior, Geological Survey, Surface Water Records of Arkansas, various years through 1964. Little Rock, Arkansas: U. S. Geological Survey.

15. U. S. Department of the Interior, Geological Survey, Surface Water Records of Missouri, various years through 1964. Rolla, Missouri: U. S. Geological Survey.

16. U. S. Department of the Interior, Geological Survey, Low Flow Characteristics of Streams in the Mississippi Embayment in Northern Arkansas and in Missouri, Geological Survey Professional Paper A48-F. Washington, D. C., Government Printing Office, 1966.

17. U. S. Department of the Interior, Geological Survey, Compilation of Records of Surface Waters of the United States, October 1950 to September 1960, Part 7, Geological Survey Water-Supply Paper 1731. Washington, D.C., Government Printing Office, 1964.

18. U. S. Department of the Interior, Federal Water Pollution Control Administration, Pollution Caused Fish Kills in 1965. Washington, D. C., Government Printing Office.